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Are We Adapting to Climate Change? Evidence from the High-Quality Agri-Food Sector in the Veneto Region

Dana Salpina * and Francesco Pagliacci

Department of Land, Environment, Agriculture and Forestry, Università degli Studi di Padova, 35020 Legnaro, PD, Italy
* Correspondence: dana.salpina@unipd.it

Abstract: Adaptation to climate change is an issue of growing concern for the agri-food sector, particularly for Geographic Indications (GIs). Agri-food GIs are deeply grounded on the concept of terroir, whose key aspects can be altered by climate change. In this context, understanding whether and how agents involved in agri-food GIs production are adapting to climate change is a crucial issue, together with pointing out the role played by either economic incentives or subsidies in the implementation of adaptation measures. To answer these questions, this research focuses on the case of the agri-food sector of the Veneto Region. First, a subsample of agri-food GIs is identified. Second, a mixed-methods approach is implemented, including 14 semi-structured in-depth interviews with key informants and two focus group discussions to analyze the effects related to climate change and the implementation of adaptation measures. Different levels of concern regarding the effects of climate change are observed. Similarly, the implementation of adaptation measures largely varies in relation to the type of GI (e.g., animal-based or crop-based), crop system (annual or permanent crops) and altitude of the production areas (e.g., mountains or plain). Additionally, several groups of barriers to adaptation are outlined, including behavioral, socioeconomic, policy- and governance-related, informative and structural ones. Several recommendations are suggested: de jure recognition of the current functions of some Consortia and Producers Organizations, scaling up adaptation strategies beyond the GI system through cooperation and institutionalized networks and developing knowledge provision systems based on participatory approaches.

Keywords: geographical indications; climate change; adaptation

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1. Introduction

Climate change is already influencing crop yields and livestock productivity in Europe and is expected to continue affecting the productivity of agri-food sectors across the world [1]. Additionally, the increased frequency and intensity of extreme weather-related and climate-induced events lead to increased crop losses and the reduced quality of agri-food products [2]. The impact of climate change on agriculture varies depending on the farming systems [3], different in sensitivity and exposure to changes [4]. However, traditional and smallholder agricultural systems are considered particularly vulnerable to climate change risk [5]. In this regard, adaptation to climate change is becoming an issue of growing interest and concern for the agri-food sector worldwide [6–9]. However, little attention has been paid to the nexus between climate change and Geographic Indications (GIs) as a collective certification system.

High-quality agri-food systems, such as those grounded on GIs, are of particular interest. In the EU, GI schemes, such as Protected Designations of Origins (PDO) and Protected Geographical Indications (PGI), protect specific know-how, authenticity and agro-environmental conditions. They are granted to those products associated with traditional agricultural practices and well-defined geographic areas (i.e., terroirs) that identify them. Climate change has already altered some key aspects of terroir, hence affecting the agricultural productivity and profitability of GIs [10]. As compared to more conventional agri-food systems, the production of agri-food GIs suffers from additional constraints. Firstly, they cannot be easily moved, due to the tight definition with the area of production (i.e., the terroir and its boundaries). Secondly, every modification of agricultural practices codified in Product Specifications, i.e., a document required by Article 7 of Regulation (EU) No. 1151/2012, which contains key information concerning a GI product (such as its name, methods and geographic area of production), is a time- and resource-consuming process [11]. In addition to legal bindings, the adaptation of agri-food GIs to climate change is hindered by a complex interaction of ecological, economic, policy and social processes on which the agri-food systems rely. In this context, this research aims to answer the following research questions: whether and how agents involved in the production of agri-food GIs are adapting to climate change and what the role is played by either economic incentives or subsidies in the implementation of any adaptation actions.

Similar studies considered only the wine sector [12,13]. In the wine sector, the economic agents are used to develop coordinated lobbying actions and collectively cope with climate change effects [14], whereas the agri-food GIs miss this opportunity because of their more heterogeneous nature.

In order to fill the existing knowledge gap, this study focuses on the case of the Veneto Region in Italy. To study climate change adaptation of the agri-food GIs, first, a subsample of agri-food GIs is identified, covering different types of GIs (e.g., animal-based and crop-based GIs). Second, the responses of GI agents to the effects related to climate change are analyzed using a mixed-methods approach. Accordingly, 14 semi-structured in-depth interviews with key informants are conducted, together with two focus group discussions (FGDs).

2. Conceptual Tangles: Types of Adaptations in Agriculture

In the last decades, a bewildering array of concepts have been used to study how agricultural systems cope with and adapt to climate variability. These multiple (and interrelated) concepts may have implications for the provision of knowledge [15]. Therefore, we find it useful to draw a distinction between the multiplicity of concepts referring to adaptation in agriculture before embarking on a discussion of the study methods.

The first concept to be clarified is the difference between mitigation and adaptation. In agricultural studies, previous research mostly adopted the definitions given by the climate change literature, which frames adaptation as "the process of adjustment" to actual or expected climate change effects. In particular, adaptation seeks "to moderate or avoid harm" or exploit beneficial opportunities [16] (p. 118). However, according to Ensor et al. (2019), there is substantial differences between adjustments to climate impacts and adaptation to climate change [17]. This latter is placed within "long-term transformations" in agricultural households (p. 228). Conversely, mitigation in relation to climate change is defined as an intervention "to reduce the sources" or "enhance the sinks of greenhouse gases" [16] (p. 125). In relation to disaster risk, mitigation is defined differently as "the lessening" of the potential adverse impacts of physical hazards through actions that "reduce hazard, exposure, and vulnerability" [18] (p. 561). In other words, mitigation addresses the cause of climate change while adaptation addresses its consequences. Additionally, Fedele et al. [19] pointed out the role of coping among those strategies that aim to reduce the impact of climate change on social–ecological systems in agriculture. However, as compared to adaptation, coping does not introduce alterations to the existing socioecological system (e.g., watering plants and replanting damaged plants); hence, it can be effective only when the impact is not particularly intense.

As a second conceptual issue, the wide variety of agricultural adaptations to climate change must be addressed, which vary according to their forms (technological or behavioral); scale of application (farm, system and landscape levels); governance (farmers, consortia, region and state); timing (reactive, concurrent and anticipatory); duration (short- or long-term) and intensity of the adaptation measure (tactical and strategical) [20]. In agriculture, few overarching categories can be distinguished based on the scope of the adaptation strategies (Table 1).

Table 1. Categories of adaptation in agriculture. Source: authors' elaboration.

Reference	Variable to Define Adaptation	Adaptation Categories		
		Incremental	Systems Adaptation	Transformational
[16]	Intensity of climate change impact	Low	Medium	High
[17]	Systems	Conventional systems	Certification (e.g., organic and GIs)	Integrated landscape systems
[17]	Complexity of implementation	Low	Medium	High
[15]	Continuance of change	Short-term	No information	Long-term
[14,15]	Complexity of alteration	Minor adjustments("fine tune")	No information	Fundamental changes

In particular, Howden et al. [21] distinguished between incremental and transformational adaptations, which are applied depending on the degree of impact, the likely increasing complexity of implementation, its costs, associated risks and the plurality of the stakeholders involved. In other terms, transformative adaptation is more suitable when the impact intensity is higher. Additionally, incremental, transformational and systems adaptations can be distinguished in relation to the types of systems [22]. According to this theory, systems adaptation fits best at the certification level (e.g., integrated pest management), whereas incremental and transformational adaptations concern conventional and integrated landscape systems, respectively. However, the distinction between incremental and transformational (behavioral) adaptation relies not only on the level at which they are adopted but rather on the continuance of change and complexity of alterations in the existing system [20]. In practical terms, short-lived technological fixes can be categorized as incremental adaptations, although they are implemented at the managerial level (e.g., introduction of new crop varieties), while transformational adaptations are fundamental long-term changes in the system (e.g., relocation of the production area).

In addition, based on the object of transformation, Few et al. [23] highlighted a subtle difference between transformational adaptation—i.e., adaptation that takes the form of transformation—and transformative adaptation—i.e., adaptation that generates transformation. They are not exclusive. Actually, transformative adaptation is often articulated as a "deeper form" of transformational adaptation, resulting in fundamental changes and interactions within the existing socioecological systems, i.e., policies and governance measures aimed at reducing risks related to climate change vulnerability and/or taking advantage of climatic changes [24]. Additionally, incremental adaptations can have a transformative character, whereas transformational adaptation does not necessarily lead to transformative changes [23]. Following these lines of reasoning, the relocation of the production area (transformative adaptation) does not guarantee the reduction of climate change vulnerability of an agri-food system (transformative adaptation).

3. Materials and Methods

To study climate change adaptation of the agri-food GIs in the Veneto Region, first, a subsample of agri-food GIs is identified. Second, the responses of GI agents to the effects related to climate change are analyzed using a mixed-methods approach (14 semi-structured in-depth interviews with key informants and two FGDs).

3.1. Climate Change and Interannual Climate Variability in the Veneto Region

Veneto is a large region (with a total area of 18,345 km^2 and a population of about 5 million people) located in Northeastern Italy. It covers both part of the Po Valley and part of the Alps. With regards to the agri-food GI system, Veneto hosts 36 different agri-food

GIs, with a large heterogeneity in terms of both certifications (i.e., including both PDO and PGI) and product types (i.e., cereals, fruits and vegetables, meat and cheeses) [25].

When addressing the impact on agricultural and agri-food activities, both climate change and climate variability matter [1,26]. Climate change is appreciated only over a longer timeframe (usually 30 years, at least), and it identifies long-term climatic trends. Conversely, climate variability refers to the anomalies of climatic statistics over a given period, operating on a shorter timeframe (e.g., at the interannual scale).

With regards to climate change, Veneto has experienced an increase in both the summer and winter average temperatures [27]. According to the data made available by the European Data Journalism Network, it can be observed that the Veneto Region has experienced a steady growth of the average annual temperature since 1990 (Figure 1).

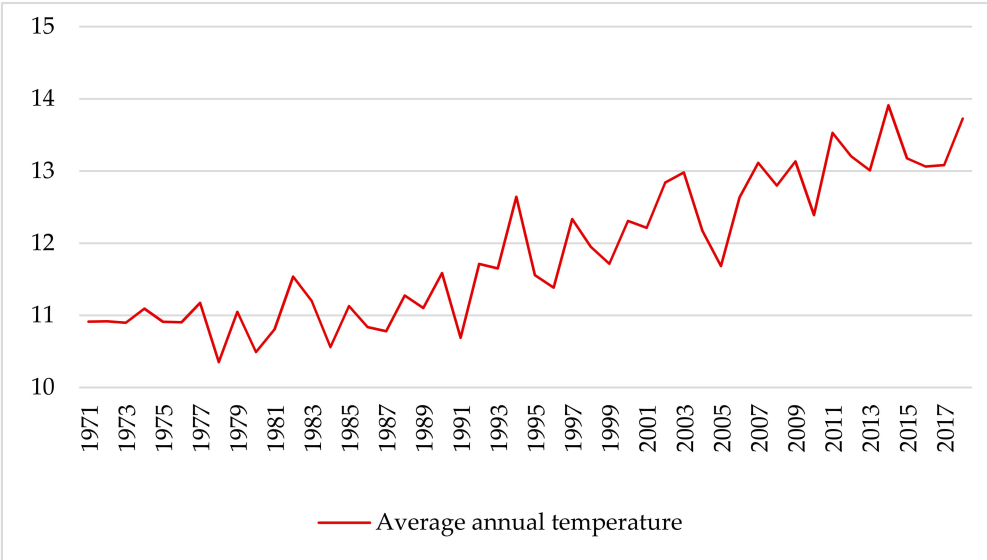


Figure 1. Average annual temperature (in degrees Celsius) in the municipalities of the Veneto Region from 1971 to 2017. Source: authors' elaboration on the Ferrari and Gjergji [28] data, which show for each EU municipality (i.e., LAU2—level region) the overall average temperature (in degrees Celsius) for the period 1961–1970 and the average annual temperature (in degrees Celsius) for each year from 1971 to 2018. See [28] for further methodological details.

As for the precipitation, the *Consiglio regionale del Veneto* [29] points out a negative trend in both annual and winter rainfall when considering data from 1956 to 2004. Moreover, Sofia et al. [30] also observed a significant trend towards a concentration of the rainfall in the long term. This eventually turns into more frequent flood events alternating with prolonged droughts.

In this specific regard, a tendency towards a greater interannual climate variability is also observed. For example, the average annual precipitation of 2010 and 2014 represent the absolute maxima of the last 60 years [31], while, in 2017, the pluviometric deficit reached −16%, as compared to the average in the period between 1993 and 2016 [32].

3.2. Data: The Subsample of Agri-Food GIs

Previous works by Salpina and Pagliacci [33] and Pagliacci and Salpina [34] have already addressed the effects of climate change on GIs in the Veneto Region. The authors performed a cluster analysis of the agri-food GIs to account for their large heterogeneity in the region. In particular, six groups of agri-food GIs were identified, according to their key features: GI type, GI category, total revenue, period of registration, share of production in Veneto and the number of municipalities covered by the production area [33].

Table 2 shows the classification of the Veneto agri-food GIs into the six extracted clusters and distinguished by crop-based (annual and permanent crops) and animal-based GIs.

Table 2. Agri-food GI clusters in the Veneto Region. Source: adapted from [33].

Clusters	**Agri-Food GIs in the Veneto Region**		
	Annual Crop	**Permanent Crop**	**Animal Based**
Little revenue PDOs	Asparago Bassano	Garda oil, Marrone San Zeno	Prosciutto Veneto Berico Euganeo, Cozza Scardovari
Large-scale PDO cheeses			Grana Padano, Asiago, Monte Veronese, Taleggio, Montasio, Provolone
Second-generation PDOs	Aglio Bianco Polesano	Veneto Valpolicella olive oil	Salamini Cacciatora, Soppressa Vicentina, Miele Dolomiti Bellunesi, Casatella, Piave
Unexploited opportunities			Salami Cremona, Mortadella Bologna, Cotechino Modena, Zampone Modena
First-generation crop PGIs	Radicchio Verona, Radicchio Rosso Treviso, Fagiolo Lamon, Radicchio Variegato Castelfranco, Riso Nano Vialone Veronese		
Second-generation crop PGIs with little revenue	Riso Delta del Po, Insalata Lusia, Radicchio Chioggia, Asparago Bianco Cimadolmo	Ciliegia Marostica, Asparago Badoere, Pesca Verona, Marrone Monfenera, Marrone Combai	

Grounded on these results, a subsample of agri-food GIs in the region is identified. Although the subsample is not statistically representative, it is selected in order to have a smaller number of cases where in-depth first-hand data can be retrieved [35]. In particular, to select the subsample for the interviews, each of the 6 clusters of agri-food GIs is considered. The objective is to ensure the representation of each cluster and heterogeneity of the selected agri-food GIs. Accordingly, the final subsample is composed of 3 animal-based PDOs, 3 crop-based PDOs and 5 crop-based PGIs, as listed below:

- Asparago Bianco di Bassano (asparagus);
- Ciliegia di Marostica (cherry);
- Fagiolo di Lamon (bean);
- Monte Veronese (cheese);
- Radicchio di Chioggia (chicory);
- Radicchio Rosso di Treviso (chicory);
- Riso Nano Vialone Veronese (rice);
- Olio Veneto (olive oil);
- Casatella Trevigiana (cheese);
- Piave (cheese);
- Marrone di San Zeno (chestnut).

The selected subsample covers all the provinces of the region (Figure 2 shows the municipalities that are eligible for the production of each of them, according to their Product Specifications) and products with very heterogeneous characteristics (Table 3).

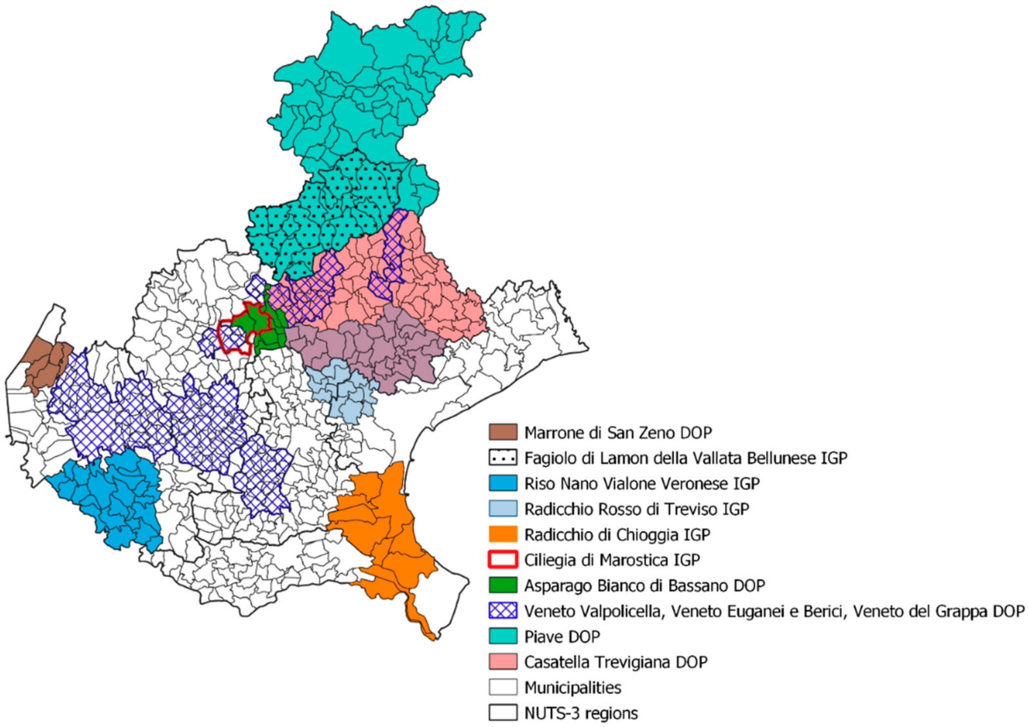


Figure 2. Geographic distribution of the case studies.

Table 3. Characteristics of the case study GIs. Source: authors' elaboration on [36] for ([a]). [37] for ([b]), [25] for ([c]) and data from Production Specifications for ([d]).

GI	Type *	Scheme [a]	Registration Year [a]	No. of Operators [b]	Production Area (Ha) [b]	Production Volume (kg/lt) [c]	ProductionCycle (Month of the Year) [d]
Asparago B. di Bassano (asparagus)	AC	PDO	2007	56	14	40.0	03–06
Ciliegia di Marostica (cherry)	PC	PGI	2002	121	58	13.0	03–08
Fagiolo di Lamon (bean)	AC	PGI	1996	81	12	9.7	05–09
Monte Veronese (cheese)	AB	PDO	1996	140	3093	893.9	01–12
Radicchio di Chioggia (chicory)	AC	PGI	2008	32	97	124.8	12–07
Radicchio R. di Treviso (chicory)	AC	PGI	1996	114	303	894.6	06–12
Riso Nano V. Veronese (rice)	AC	PGI	1996	28	524	530.8	04–09
Olio Veneto (olive oil)	PC	PDO	2001	290	371	39.0	03–12
Casatella Trevigiana (cheese)	AB	PDO	2008	70	1427	314.3	01–12
Piave (cheese)	AB	PDO	2010	180	NA	1.583	01–12
Marrone di San Zeno (chestnut)	PC	PDO	2003	29	52	12.7	03–11

* Type classification: AC—Annual crops, PC—Permanent crops and AB—Animal-based products.

3.3. Method

To analyze the responses of the agents involved in the GI production to climate-related hazards, a mixed-methods approach was implemented, according to the description shown in Table 4.

Table 4. Summary of the data collection methods.

Phase	Method	Sampling Strategy	Sample Size and Participants	Purpose	Timeframe	Tools for Data Analysis
I	In-depth semi-structured interviews	Purposive sampling	14 key informants (Consortia/Producers Organizations) 6 annual crop GIs 6 animal-based GIs 2 permanent crop GIs	Collecting climate change observations and perceived effects on GI production; identifying the main adaptation practices (if any) and perceived barriers to adaptation.	June–November 2021	RQDA (R studio)
II	Focus group discussions (FGD)	Convenience and snowball sampling	FGD #1: 4 participants from 4 animal-based GI systems; FGD #2:10 participants from 4 crop-based GI systems	Enhancing some of the key issues captured during phase I and the results of the individual interviews	December 2021–January 2022	RQDA (R studio)

3.3.1. Semi-Structured Interviews

Phase I of data collection included semi-structured in-depth interviews, which were conducted in order to (i) capture climate change observations and perceived effects on GI productions and (ii) identify the main adaptation practices (if any) and perceived barriers to the adaptation (if any). In particular, the last objective was addressed considering the role of coordinated strategies at the managing authority level and focusing on the role of economic incentives to support mitigation/adaptation actions in the framework of GIs.

According to these objectives, the interview guide was structured according to 6 main themes: (1) introduction and warm-up questions, (2) observations of climate change and its effects on GI production, (3) adaptation methods, (4) governance and coordination, (5) public incentives and policies and (6) ending questions to allow GI agents to express their observations freely and to ask questions. The questions were slightly adapted to each specific interview, following a preliminary analysis of the web site of the home organization, gray literature and information on the interviewees' profiles (education and experience). Moreover, the interview questions were adjusted slightly as the research evolved to capture new, important themes or constructs (for more details, see Appendix A).

Two types of entities were considered, namely the Consortia (*Consorzio di Tutela*) (whose functions are defined by an Italian law, under Art. 14 of Law No. 526/1999) and Producer Organizations (POs), as they are able to provide a broader vision on the current situation of GI productions, problems faced by farmers in view of the climate change and tools they apply to adapt to the changing climate conditions. Participant selection for the interviews was grounded in purposive sampling [38] based on their position in organizations (i.e., senior decision-making roles). In particular, managers were contacted for their expert knowledge of the production process and decision-making role within GI systems. In most of the cases, the representatives of the Consortia are also producers themselves. However, when it was not possible to reach the representatives of the Consortia and POs, other economic agents, such as an agrarian of a Consortium, were interviewed.

Overall, 14 key informants of the Consortia and POs were interviewed from June 2021 to December 2021. The interviews were conducted mostly face to face. Telephone, video calls and email interviews were also used when it was not possible to meet in person due to logistic issues or time convenience. All face-to-face interviews were conducted in the places selected by interviewees in order to ensure their confidence. On average, each interview lasted between 25 and 40 min.

All interviews were digitally recorded. Overall, around 7 h of interviews were transcribed verbatim with the help of an open-source web app *oTranscribe*. To make data identification manageable, unique alphanumeric codes were used to label the transcripts (Table 5).

Table 5. Characteristics of the interviews.

Interview ID *	Interviewee	Type of Entity	GI	Type of the Interview
IAC01	Manager, producer	Consortium	PDO	face-to-face
IPC02	Producer	Consortium	PDO	face-to-face
IAC03	Manager, producer	Consortium	PGI	face-to-face
IPC04	Manager, agrarian	Consortium and PO	PDO	face-to-face
IAC05	Expert advisor	Consortium	PGI	video call
IAB06	Manager	Consortium	PDO	video call
IAC07	Manager	PO	PGI	video call
IAC08	Manager	Consortium	PGI	phone call
IAB09	Manager, producer	Consortium	PDO	phone call
IAC10	Manager, producer	Consortium	PGI	email interview
IAB11	Producer	Dairy factory	PDO	phone call
IAB12	Manager, producer	PO	PDO	phone call
IAB13	Manager	Consortium and PO	PDO	phone call
IPC14	Manager, producer	Consortium	PDO	phone call

* Decoding of Interview ID: I—Interview, AC—Annual crop, AB—Animal-based, PC—Permanent crop and 01—ID of the interviewee.

3.3.2. Focus Group Discussions

Phase II of the data collection encompassed FGDs used to enhance some of the key issues captured during the key informant interviews. Therefore, the FGDs were mostly grounded on the results of the interviews.

Focus groups are conversations in small groups of people on a specific topic with the aim of getting to know the group's opinion on a specific research topic [39]. The FGD composition is important, assuring the heterogeneity of the participants and creating a comfortable atmosphere, ensuring the group dynamics. According to this research setting, 2 FGDs were held: 1 for the agents of crop-based GIs and 1 for the agents of animal-based GIs. This choice ensured a more fruitful discussion, because of similar phenological characteristics.

The recruiting strategy for the FGDs was based on convenience and snowball samplings. Although these nonprobability sampling techniques are rarely representative of the target stakeholders (producers and managing authorities), they respond to our objective of collecting in-depth qualitative information that enhances the results of the interviews. First, the members of the Consortia that participated in the in-depth interviews were invited to the FGDs (convenience sampling), and then, they were asked to suggest producers of their GI systems who might be interested in participating in the FGDs (snowball sampling) [40]. For the FGD of animal-based GIs, the Consortia of 2 additional GIs were invited, i.e., one of the ham Prosciutto Veneto PDO and one of the cheese Provolone Valpadana PDO, in order to gain more complete results for the animal-based GIs. In all, the FGDs consisted of 14 participants (9 for crop-based and 4 for animal-based GIs) (Table 6).

Table 6. Characteristics of the participants in the focus groups.

FGDs	FGD Participant ID *	Participant	Type of Entity	GI
FGD #1	FGPC1	Manager, Producer	Consortium	PGI
FGD #1	FGPC2	Producer	Farm	PGI
FGD #1	FGPC3	Manager	PO	PGI
FGD #1	FGPC4	Producer	Farm	PGI
FGD #1	FGPC5	Marketing	Consortium	PGI
FGD #1	FGPC6	Producer	Farm	PGI
FGD #1	FGPC7	Manager	Consortium, PO	PGI
FGD #1	FGPC8	Producer	Farm	PGI
FGD #1	FGAC9	Expert Advisor	Consortium	PGI
FGD #1	FGAC10	Manager producer	Consortium	PGI
FGD #2	FGAB11	Manager, producer	Consortium	PDO
FGD #2	FGAB12	Manager, producer	Consortium	PDO
FGD #2	FGAB13	Manager, producer	PO	PDO
FGD #2	FGAB14	Producer	Dairy factory	PDO

* Decoding of the FGD participant ID: FG—Focus group, AC—Annual crop, AB—Animal-based, PC—Permanent crop and 01—ID of the participant.

The planning of each FGD included: (i) developing a recruiting strategy, (ii) developing the FGD guides with questions and (iii) preparation of the stimulus materials [41]. The structure of the FGD guides and stimulus materials followed the same structure for both FGDs, but the questions were slightly adapted. The focus group design comprised three major parts. First, a quick introductory round took place, where participants were asked to share some personal information and the moderator introduced the whole project, as well as the goal of the discussion. Then, the first round of the discussion was dedicated to adaptation and innovative practices. For analytical simplification, the responses of the key informants in terms of climate change effects and adaptation practices were grouped into broader categories and were employed as stimulus materials. Participants were asked to exchange opinions regarding the list of presented adaptation practices/methods (Q1: Which of the practices are more or less successful? For what reasons?). The second round of the discussion was dedicated to the perceived barriers to adaptation (Q2: Are there any barriers to adopting these practices at the system level?).

Discussions in the focus groups were moderated by two university researchers. Both FGDs were conducted remotely for the convenience of participants located in different parts of the region. Similar to individual interviews, both FGDs were digitally recorded with the consent of participants and manually transcribed.

3.3.3. Data Analysis

The transcripts of in-depth interviews and the FGDs were analyzed via thematic analysis [42], resulting in emerging commonalities and differences in terms of climate change observations and adaptation tools among the subsample of GIs in the Veneto Region. RQDA, i.e., an open-source computer-assisted qualitative data analysis (CAQDAS)-based R extension, was used to create codes and code categories [43].

Since the interviews were semi-structured and already included predefined themes unfolding the research questions (e.g., climate change observations and adaptation methods), a hybrid approach of deductive (top-down approach) and inductive (ground-up approach) coding was used [44] (for more details, see Appendix B). A similar approach of analysis was used for the FGD, with the exception that FGDs are analyzed aggregately for crop-based GIs and for animal-based GIs. In other words, each FGD piece of data was considered as a unit of analysis (and not each single GI or participant).

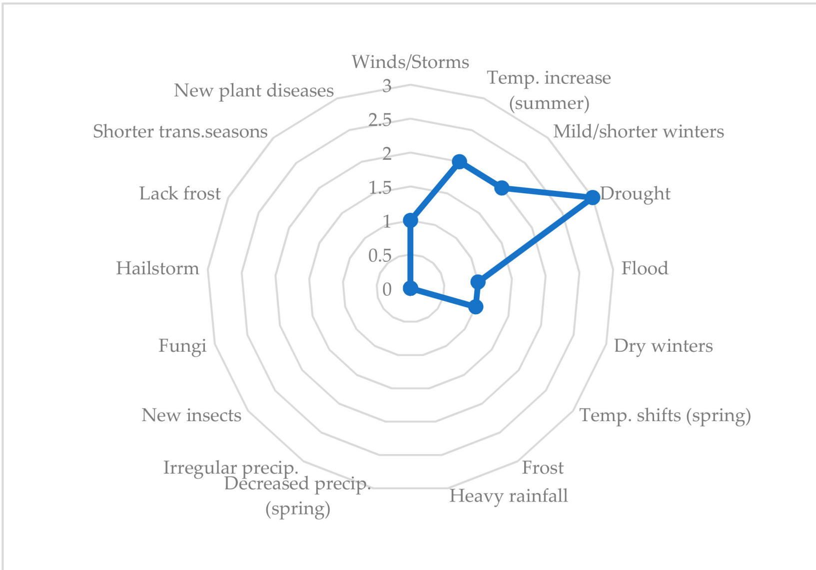
The observations on climate change and emerging practices of adaptation were analyzed based on the frequency of their appearance in the interviews and FGDs.

4. Results

4.1. Climate Change Observations and Their Effects on the GI Systems

The results show that climate change observations vary largely in relation to the type of GI (i.e., animal-based or crop-based) and crop system (i.e., annual or permanent crops), as well as altitude of the production areas (e.g., mountain and flatland). Figure 3a–c show the observations of the three different groups of GI agents that are associated with climate change either directly (e.g., temperature and precipitation variability) or indirectly (e.g., increase of fungal diseases) [45].

(a)



(b)

Figure 3. *Cont.*

(**c**)

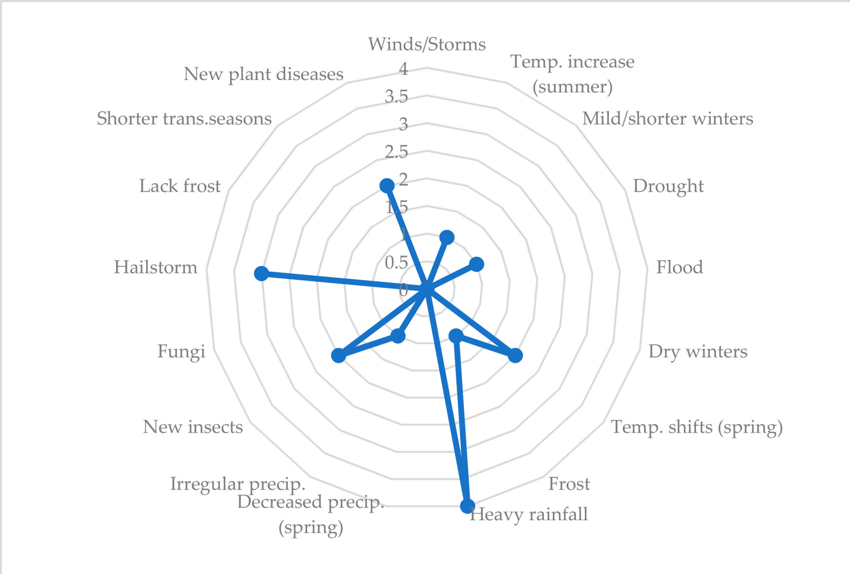


Figure 3. Observations on the climate change: (**a**) animal-based GIs, (**b**) annual crop-based GIs, (**c**) permanent crop-based Gis.

According to these results, the key informants of all animal-based GIs (i.e., PDO cheeses) are mostly concerned with concentrated heavy rainfalls, which, during the last few years, strongly affected forage availability in the delimited production areas. In the case of cheese GIs that are produced in the mountain areas, heavy rainfalls are accompanied by strong winds, storms and even floods, as claimed by one of the respondents:

> *"Last years, there have been some calamitous events, such as persistent rains and storms, which greatly penalized the production of local forages". [IAB06]*

However, the loss and reduction of forage due to drought and heat stress in cattle is less of an issue for mountain-based GI cheeses as compared to those produced on the plain. This finding is in line with Vitali et al. [46], who highlighted an increased risk of heat stress for dairy cows in the Po Plain, where the Veneto Region is located.

Similarly, the variation of climate change effects based on the elevation of the production is observed for crop-based GIs. However, in the case of crop-based GIs, the variation of climate change effects is also observed within one single GI system. For example, as reported by a producer of the cherry GI Ciliegia di Marostica, the farms located in the hilly area within the boundaries set by the Product Specification are more protected from climate change events than those in the lowlands, particularly in terms of frost events (FGPC4).

Considering the type of production, the key informants of crop-based GIs report a much broader diversity of climate change observations. Increased and prolonged precipitation is among the most frequently cited observations for crop-based GIs. In particular, key informants express their main concern for the increased precipitation in the spring and autumn, corresponding to the critical periods of the crop growth cycle, which often have consequences on the production volumes and harvest delays. For example, the prolongation of rainfall up to 4 or 5 days during the ripening period of cherries frequently causes cracking of the fruits and "loss of its prestige" (IPC02) (i.e., a reduction of the product quality). Similarly for annual crop GIs, prolonged precipitation during the harvesting period seems to considerably reduce the accessibility of crop fields, causing the loss of production and production delays, as was the case in the autumn of 2019 when producers of chicory GI Radicchio Rosso di Treviso lost 15–20% of their productions (IAC08). In addition, this annual crop suffers from the lack of autumn frost (as a consequence of the warming in the area), which plays an important role in its production and quality (IAC08).

Another major issue for most crop-based GIs are sudden shifts of spring temperatures causing a delay of sowing for rice and beans GIs, decreased fruit sets for cherry and olive GIs and bolting in the case of chicory GIs. Additionally, climate change observations concerning only a certain type of GIs should be noted.

Climate change observations for permanent crop GIs mostly correspond to what is reported for annual crop GIs. In addition, new plant diseases seem to be the main concern for the farmers of permanent crops. For example, the key stakeholders of Olio Veneto (based on a permanent crop) associate the desiccation of olive tree brunches and the attacks of phytopathogenic microorganisms (i.e., Botryosphaeria) with climate change. Interestingly enough, the link between the emergence of a new plant disease and climate change is denied by a key informant of chestnut GI Marrone di San Zeno:

> *"There are some new diseases; we have been able to control some of them. But everything is in the norm, there aren't these big weird problems . . . I don't see the damages to blame climate change." [IPC14]*

On the one hand, such an observation can be related to the fact that this type of GI chestnut is mainly produced in hilly and mountain areas, where the effects of climate change are less pronounced, similar to the case of mountain-based PDO cheeses. On the other hand, it can also be evidence of the low perception of climate change effects by this key informant [47].

For the two other permanent crop GIs considered in this research (i.e., cherry and olive oil), both in-depth interviews and FGDs demonstrated an increasing concern for the long-term effects of climate change. Impacts easily translate to the productive sphere, thus increasing the risks (e.g., reduction of income level and income stability as a consequence of the effects of climate change on productivity [45]. These risks are not only suffered by the single GI producers but also by the overall agricultural systems (FGPC8).

Additionally, GI agents were concerned about the effects of climate change on the rural systems that rely on GI productions:

> *"Defending the GI product means defending the farmers, and also defending the territory. If people work and make money here, they will stay. If people close everything, they will leave the territory". [IPC02]*

In relation to these observations on climate change and their effects on agri-food GIs, some adaptation practices are already emerging on both the farm and GI levels.

4.2. Emerging Practices of Adaptation to Climate Change

Adaptation measures reported by GI agents vary considerably when considering animal-based, annual crop and permanent crop GIs. However, a few adaptation measures are shared, including managerial measures, which also include modifications of Product Specifications or the subscription of insurances and use of protective covers (in particular, anti-hail covers), as well as interventions regarding crop varieties and irrigation (see Figure 4).

Moreover, it is possible to observe that the multiplicity of the effects of climate change that key informants of crop-based GIs have mentioned are reflected in the larger amount and diversity of the adaptation measures implemented at both the farm and GI levels. Conversely, less diversity of the adaptation measures is reported by the key informants of animal-based GIs, who had already reported fewer observations, and of types regarding climate change (see Figure 3a–c).

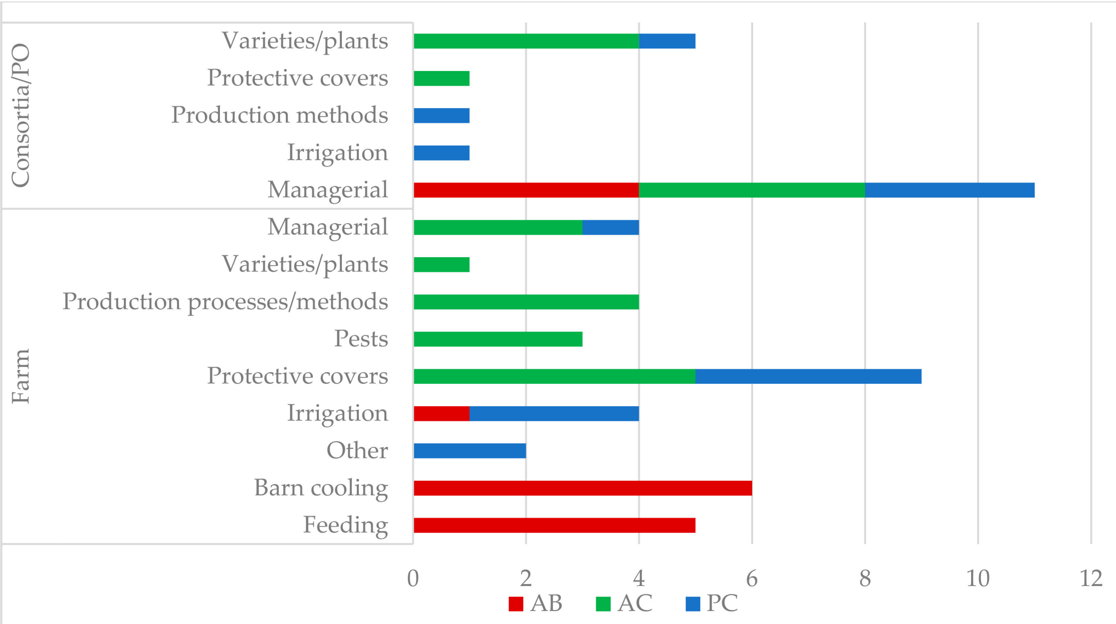


Figure 4. Number of emerging practices of adaptation to climate change among the respondents, by the selected GIs in Veneto, distinguishing by type: annual crops GIs (AC), animal-based GIs (AB) and permanent crops GIs (PC).

4.2.1. Adaptation at Farm Level

At the farm level, GI agents mainly outline incremental adaptation measures [19,20] concerning the production process and methods, irrigation and production area.

As the response to prolonged precipitation in transitional seasons, the most frequently used adaptation practices concern the production processes (e.g., postponed sowing in the case of beans and rice) and methods (e.g., transplanting instead of direct seeding in camps), as well as the use of covers against hailstorms and heavy rainfall.

A number of adaptation measures related to irrigation techniques are highlighted, ranging from the extension and introduction of an irrigation system, where it was not used before (e.g., by means of simple tube irrigation (IAC05)), to more sophisticated irrigation systems, such as micro-irrigation and gravity-fed drip irrigation (IPC02).

Additionally, in the case of animal-based GIs, mainly tactical measures directed to specific climate-induced issues are implemented. Thus, the key informants of cheeses Casatella Trevigiana and Monte Veronese report that, during the last few years, many farmers started to install various cooling systems for their barns (e.g., distilled water showers and ventilators) to cope with elevated temperatures during the summer periods. According to Schauberger et al. [48], the reduction of heat stress by means of air-cooling devices can be seen as a contribution to strengthen the economic resilience of farmers, especially in confined livestock systems (such as Casatella cheese). In addition, the import of fresh forage from highlands and water from plains, as well as the use of mountain pastures, are practiced during hot summers.

Only a few transformational practices at the farm level were identified during the research, for example, the expansion of the actual production area to higher altitudes in the case of mountain-based GIs (e.g., bean Fagiolo di Lamon and cheese Monte Veronese) (IAC05 and IAB09). However, it is important to consider that the Production Specifications of some GIs define a vast production area, which gives the producers an opportunity to expand their productions to higher attitudes.

Overall, it must be noticed that the measures of adaptation at the farm level highlighted by this research are not different from the ones observed on more conventional farms and found in other studies on climate change adaptations in the same region (for example, see [49]) or elsewhere [50,51]. However, what makes the GI systems different is the existence of a GI system level, in addition to farm-level adaptations. Indeed, every GI is expected to cover a “collective” production process [52] (p. 497) representing a “type of collective property” [53].

4.2.2. Adaptation at the GI Level

Adaptation measures of a more strategic or transformational nature are implemented at the GI system level. In particular, the results from the interviews and FGDs suggest a decisive role of the Consortia and POs in coordinating the common strategies related to climate change, including the modification of Product Specifications, research and provision of market and advisory support.

As shown in Figure 4, managerial measures and, in particular, the modifications of Production Specifications are introduced in all types of GIs. In crop-based GIs, nonminor modifications of Product Specifications concern the broadening of the varietal range (in the case of cherries); change in the methods of production (e.g., shift of the harvesting and transplanting periods) and changes in the parameters of the length, width and thickness of the products (e.g., rice).

For animal-based GIs, the Product Specifications typically impose a minimum percentage of forage for the daily diet of cows that should come from the concerned production areas (for example, at least 70% for Piave cheese, 60% for Casatella cheese and 100% for Monte Veronese cheese). Therefore, in all cheese GIs, temporary (minor) modifications concerning the possibility to import the forage from outside the delimited production areas are introduced (e.g., Piave cheese) or are planned to be introduced (e.g., Monte Veronese cheese). However, in the case of Casatella cheese, a similar modification is also driven by pressure on the production of fodder crops from the rapid expansion of viticulture for Prosecco GI and urbanization.

In the case of crop-based GIs, the Consortia often provide advisory support and play the role of innovation intermediaries by collaborating with research organizations such as universities. Such collaborations clearly demonstrate the quest of the Consortia to find new solutions to cope with the increasing climate variability and plant diseases [54], for example, work on genetics and seed selection, experiments on new, more resistant crop varieties and virus-tolerant plants, new pruning techniques and fertilization.

However, for animal-based GIs, the situation is slightly different. In this case, the Consortia often do not have a direct face-to-face interaction with the breeders (IAB06).

In the case of animal-based GIs, this can be a reason limiting the functions of the Consortia in supporting the climate change adaptation strategy of a mere marketing agency.

Besides the Consortia, POs also play a crucial role in the adaptation of agri-food to climate change. In some cases, their roles remain limited to selling and promoting the production. However, some strategic adaptation measures were identified during the FGDs and interviews. They cover the provision of periodic advisory support to farmers based on the phenological stages of crops and data from ad hoc meteorological stations in the case of olive oil. It is important to note, though, that the functions of the Consortia and POs are often merged and implemented by the same stakeholders.

5. Discussion

In light of emerging practices of adaptation at both the farm and GI levels, it is important to define the barriers that impede or hinder the process of developing and implementing them [55]. Unlike the limits, these barriers can be overcome by the implementation of specific policies and measures [56]. Therefore, their identification is crucial in the early stages of drafting the adaptation strategies. In this section, the identified barriers are discussed against the existing literature on the topic and policy.

5.1. Barriers to Adaptation

Both interviews and FGDs acknowledge a broad variety of barriers or factors that currently impede or could potentially hinder the adaptation of agri-food GI agents to climate change. These barriers vary considerably in relation to the type of GI system.

However, there are also several points of convergence, which include the restrictions imposed by Product Specifications and the administrative burden related to the amendment of Product Specifications, low perception of climate change or its perception as a long-term risk, high average age of farmers and the lack of networks. Additionally, permanent crop GIs share multiple barriers with annual crop GIs (Figure 5).

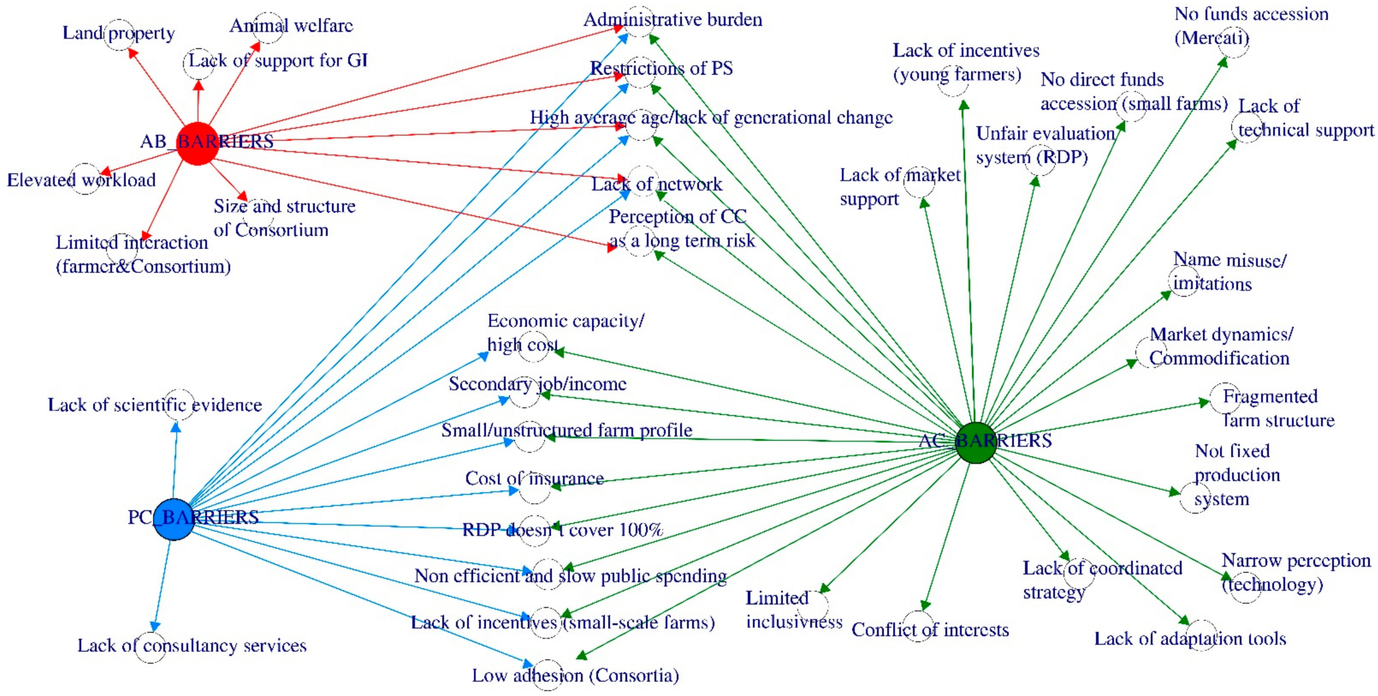


Figure 5. Barriers to climate change adaptation. Red arrows—barriers referred to the agents of animal-based GIs, blue arrows—permanent crop GIs and green arrows—annual crop GIs.

Overall, the barriers to adaptation can be grouped into the following categories: (i) behavioral barriers, (ii) socioeconomic barriers, (iii) policy- and governance-related barriers, (iv) information barriers and (v) structural barriers.

5.1.1. Behavioral Barriers

Behavioral barriers can be observed in the correlation between the perception of climate change risk and implementation of adaptation measures. Thus, the key informants who express less concern regarding climate change effects also report fewer adaptation measures to reduce the negative effects of climate change, and a lower variety. Some of them perceive the risk of climate change to their production only as a long-term risk (IAC07).

This argument is consistent with Fishbein and Ajzen [57], who claim the critical role of risk perceptions in adaptation attitudes.

5.1.2. Socioeconomic Barriers

Additionally, several participants in the interviews and FGDs report that the higher average age of famers represents one of the main barriers to adaptation. In particular, elderly farmers are felt to be less prone to the introduction of new practices, which often leads to generational conflicts (FGAB14).

This finding supports the previous work of Asrat and Simane [58], who highlighted age among the factors affecting the absorptive capacity of farmers and the adoption of new practices. A higher average age of farmers can be grouped both as a behavioral barrier to adaptation and as a barrier related to the socioeconomic characteristics of GI farmers. It is also important to consider that, for many farmers, GI production only represents a secondary income source or a seasonal activity. This aspect can potentially hinder additional investments in adaptation measures. In particular, the unstructured profiles of farms (i.e., active farmers) can impede the direct accession to regional funds [59].

5.1.3. Policy- and Governance-Related Barriers

Indeed, the key informants outline many barriers related to policy and economic incentives. This includes the lack of economic incentives for young farmers and smallholders or the difficulty of accession to these funds. In this context, smallholders mainly rely on limited private savings (IPC02).

In addition, climate risk-related insurance is mainly used in the case of fruit and olive oil GIs. However, it often remains unaffordable for smallholders, despite the subsidized insurance schemes of the Common Agricultural Policy (CAP), which was introduced in the 2014–2020 programming period (and also confirmed for the post-2020 CAP) (IAC08).

Additionally, the key informants outline the lack of market support (e.g., against unfair price rates of large retail chains, imitation and name missuses), which heavily affects the economic capacity of producers and investments in adaptation measures (IAC03).

Moreover, the restrictions and administrative burden related to the modification of Product Specification and the access to funds are highlighted as a barrier to adaptation. Thus, according to a key informant, the administrative process behind the modification of Product Specifications can require several years (IAC08).

It is important to note that the new CAP (2023–2027) can bring substantial changes to the amendment process of Product Specifications, including their simplification. However, some of the GI agents express their concern regarding the possible drawbacks of major/permanent modifications to the quality and reputation of GIs (IAB06).

Currently, for animal-based GIs, another major issue is the new policy proposal regarding the evaluation of animal welfare, which, according to key informants, can put small-quality productions at risk. However, it is also important to emphasize that, as compared to conventional agricultural systems, there is *recognition* of the potential positive role played by agri-food GIs in the "territorialisation of environmentally friendly production rules" by limiting agricultural intensification [56] (p. 94). In other words, GIs can actually become a flagship in the mitigation of climate change and contribute to environmental conservation.

Indeed, among animal-based GI systems, new strategies related to ecological transition, are emerging. These are mainly targeted at an increase of water and energy resource use efficiency. As outlined by one of the participants, these initiatives are accelerated in view of the current geopolitical problems and energy deficit (FGAB11).

Many governance-related barriers are highlighted. Specifically, the key informants outline the lack of networking and lobbying activity at the regional scale, limited interactions and poor inclusiveness of the regional decision-making strictures (e.g., *Tavolo Ortofrutticolo*), lack of collaboration among concerned stakeholders (e.g., *Consorzio di Bonifica* and other sectoral associations), size and structure of the Consortium and low adhesion to it.

5.1.4. Information Barriers

GI agents acknowledge the lack of information on climate change risks in their production areas, as well as the availability and reliability of new technologies for climate change adaptation and the lack of consultancy and technical support (FGD2). However, according to the Consortia manager of one of the cheese GIs, due to high workloads and small profits of farmers, the participation rate in multiple activities and training courses organized by sectoral associations is very low (FGAB12).

5.1.5. Structural Barriers

Finally, a few structural peculiarities of the production areas and systems are blamed for hindering the adaptation. For example, some respondents have mentioned the fragmentation of land parcels or the necessity for crop rotation, which does not allow the installation of a fixed irrigation system. Among animal-based GIs, land property can be also a barrier to adaptation, as in the case of Casatella cheese, where the land for forage production is often rented (IAB12).

5.2. Policy Recommendations

According to the IPCC Sixth Assessment Report [60] (p. 2), "*Many initiatives prioritize immediate and near-term climate risk reduction, which reduces the opportunity for transformational adaptation*." Similarly, in the case of agri-food GI in the Veneto Region, incremental adaptation measures were mainly outlined at the farm level.

Economic incentives play an important role in putting forward transformational adaptation and mitigation actions such as ecological transition. However, there are still many shortcomings acknowledged by the key informants, including a lack of economic incentives for the younger farmers and smallholders, difficulty of funds' accession, administrative burden and lack of market support. In particular, although much attention is paid to the adaptation to and mitigation of climate change in the new programming period of the CAP (2023–2027) (namely, the specific objective #4), most of these actions are assigned to national decisions. In this regard, Italy has received several recommendations by the EC for its own CAP strategic plans for the 2023–2027 programming period, also referring to the specific objective #4. In particular, the EC argues that the proposed plan does not contribute sufficiently and effectively to this objective, showing extreme continuity with past actions.

Agri-food GI systems are heterogeneous. Thus, there is no "one size fits all" climate change adaptation method. However, considering the barriers to adaptation identified during the research, a few policy recommendations can be highlighted.

First, the role of the Consortia and POs can be further enhanced. In particular, de jure recognition of the current functions of some Consortia and POs in the coordination of adaptation strategies could promote adaptation to climate change at the system level.

Second, scaling up adaptation strategies beyond the GI system could also be useful, although this requires tighter cooperation and institutionalized networks among those GI systems with similar risks and characteristics. Currently, collaborations among GI systems seem to occur only in relation to some promotional projects.

Additionally, knowledge provision systems based both on the top-down and bottom-up participatory approaches drawing on producers' knowledge can be useful. Indeed, the broader project—within which this study was conducted—envisages dissemination activities on climate risk and adaptation methods for selected GIs. Moreover, the research results will be completed and tested through an ongoing quantitative survey distributed to larger samples of GI farmers.

6. Conclusions

The research sought to investigate whether and how agents involved in the production of agri-food GIs in the Veneto Region (Northeastern Italy) are adapting to climate change, pointing out the role played by economic incentives in the implementation of adaptation strategies and the major existing barriers.

The mixed-methods approach, including semi-structured in-depth interviews with key informants and FGDs, resulted in the following findings.

Most of the key informants clearly perceive the effects of climate change on their productions. However, the level of concern and main observations largely vary in relation to the type of GI (e.g., animal-based or crop-based), crop system (annual or permanent crops) and altitude area (e.g., mountains or plain).

At the farm level, mainly incremental adaptation measures are outlined by GI agents, while adaptation measures of a more strategic or transformational nature are implemented at the GI system level. In particular, the decisive role of the Consortia and POs in the coordination of common strategies related to climate change is outlined.

Additionally, several groups of barriers affecting the adaptation to climate change are observed, encompassing the following types: behavioral, socioeconomic, policy- and governance-related, informative and structural barriers.

The study also showed a few limitations: in particular, the geographic scope of the study (as it addresses the adaptation to climate change of Italian farmers in a specific region) and the fact that most interviewed actors were managers of the Consortia and POs. Given these limitations, further studies could try to replicate this analysis in other geographical contexts, as well as targeting a larger set of producers.

However, to the best of the authors' knowledge, this is one of the few studies that addresses the effects of climate change and adaptation strategies with regards to agri-food GI systems, proposing a novel concept for the interpretation and analysis of the intricate relations between them.

Furthermore, these results will be used in combination with a questionnaire-based survey of farmers producing agri-food GIs in the Veneto Region in order to point out which are the best practices in terms of adaptation strategies to be implemented at the community level.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Questionnaire template for the semi-structured interviews

I. Introduction
- Could you please tell us about your association/consortium/company?
- Who are your associates and how does the collaboration among them take place?

II. Observations of climate change and its effects on GI production
- What is your opinion on the potential and current effects of climate change on the production of GIs in the Veneto Region?
- In your opinion, which GI is the most vulnerable one, due to climate change?

III. Adaptation measures to climate change
- What are the measures that farmers/producers have introduced to adapt to the effects of climate change?

IV. Governance and coordination

- Have the Consortia or producer organizations put in place collective mitigation/adaptation strategies?

V. Barriers and the role of public incentives and policies

- In your opinion, which are the main barriers to adaptation/mitigation?
- What could help GIs to adapt and mitigate the risks deriving from climate change?
- What is the role of economic incentives (e.g., in the field of the CAP) in the mitigation of risks and adaptation of GI production to climate change?

VI. Ending questions

Appendix B

First, "code categories" are created based on the themes defined in the interview guides (deductive approach). Second, excerpts of the interview transcripts are coded manually. The codes are then aggregated into the code categories by refining the existing and creating new ones (inductive approach).

Figure A1 shows the interface of the RQDA package, which is used for the analysis. On the right side, the code "Strong winds/storms" is shown. It is based on several text fragments extracted from three different interviews (i.e., IAB06, IAC01 and IAC07). For example, for interviewee IAC07, among the most "evident aspects [of climate change] are devastating thunderstorms and winds".

All such codes are associated with their specific code categories. For example, in the left bottom corner, we can see that codes "Drought", "Mild/short winter", "'Strong winds" and "Temperature increase" are associated with the code category "AB_CC Observations" (i.e., Animal-based_Climate change observations).

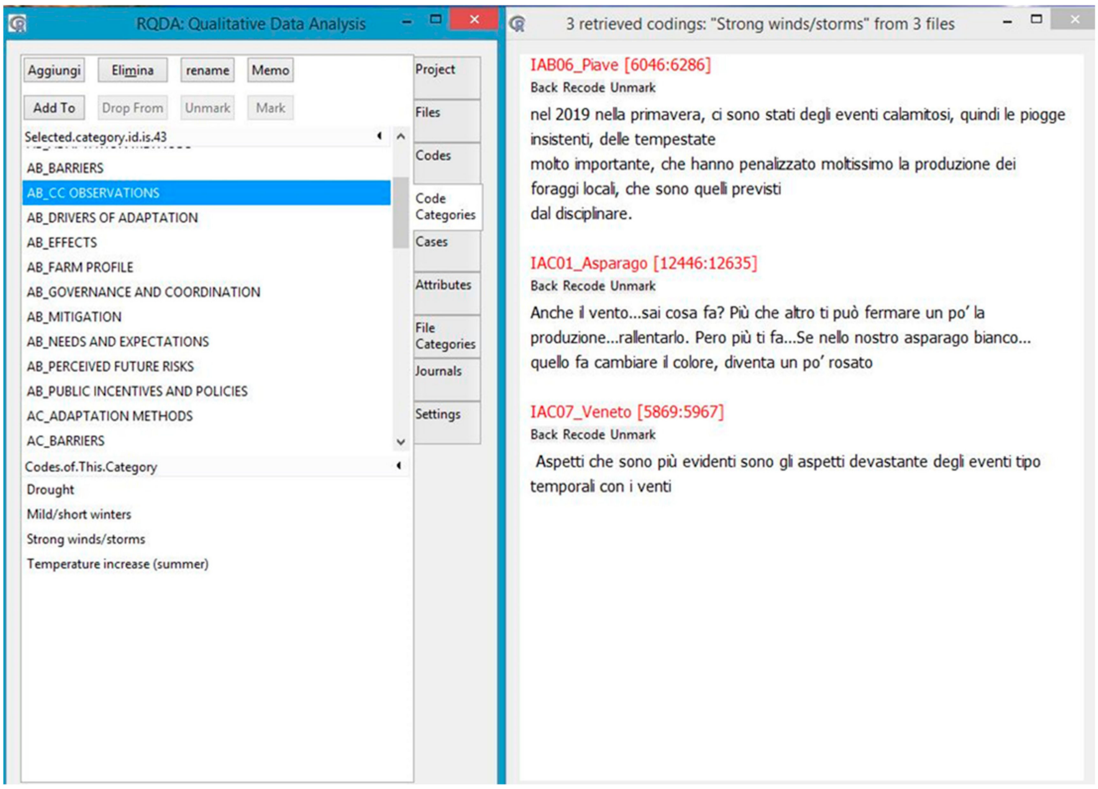

Figure A1. A sample screenshot of a code and the interface of the RQDA package.

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